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USDA Forest Service,

Rocky Mountain Forest and
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A Computer Program to Calculate the Susceptibility of Spruce-Fir Stands to Spruce Beetle Outbreaks

J. A. Logan,¹ J. M. Schmid,² and M. S. Mehl³

The computer program shows spruce beetle hazard ratings directly from data collected for stage II timber inventories.

Keywords: *Abies lasiocarpa*, *Dendroctonus rufipennis*, *Picea engelmannii*, computer programs

Schmid and Frye (1976) presented a plan for rating the susceptibility of Engelmann spruce-subalpine fir (*Picea engelmannii* Parry and *Abies lasiocarpa* (Nutt.) Hooker) stands to spruce beetle (*Dendroctonus rufipennis* (Kirby)) infestation. The plan ranks the susceptibility of the stand based on its physiographic location, basal area, average diameter of the spruce, and percentage of spruce in the overstory.

During the past 5 years, inventory projects in the Rocky Mountain Region of the USDA Forest Service have been gathering intensive data on spruce-fir stands by the methods outlined in the 1980 edition of the Region's "Silvicultural Examination and Prescription Handbook" (FSH 2409.260). Substantial information is gathered for each stand, some of which is used in the Schmid-Frye system. The data are recorded on field forms and eventually are transferred to magnetic tapes which are stored in the project's headquarters.

Since its origin, the rating system has received limited use in the southern and central Rockies. To increase its usefulness to forest managers, a computer program was

written to calculate stand susceptibility from the inventory data. The program reads the inventory file for the stand, extracts the essential information, computes the stand rating, and prints it out, identifying the stand by the location data commonly recorded.

This program may give a slightly different rating for each stand from stage II inventory data than it would if the data were gathered in the same manner as was used to develop the rating system. In Schmid and Frye (1976), the limits for each category in the basal area, diameter, and percent spruce characteristics were based on data derived from fixed radius plots. Stage II data are derived from variable radius plots and different basal area factors. How this will affect the stand rating is not known at this time, but no significant change is assumed.

The program is compatible with USDA Forest Service, Rocky Mountain Region program processing data collected from the stage II inventory. The program could be integrated into the master program of the Region to run as a subroutine so that the stand rating for spruce beetles would be automatically included in the printout with the other stand information regularly presented. There is also the possibility of a computer-produced, differentially shaded or colored, overlay map representing a mosaic of standing ratings for the different stands in the spruce-fir forest. If the Schmid-Frye rating system is adopted with modifications for regional conditions in other western regions of the USDA Forest Service, this program can also be easily modified for use with it.

¹Assistant Professor, Zoology and Entomology, Colorado State University.

²Entomologist, Rocky Mountain Forest and Range Experiment Station. Headquarters is at Fort Collins, in cooperation with Colorado State University.

³Forester, Timber Inventory, Rocky Mountain Region, USDA Forest Service, Fort Collins, Colo.

Literature Cited

Alexander, Robert R. 1967. Site indexes for Engelmann spruce. USDA Forest Service Research Paper RM-32, 7 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Schmid, J. M., and R. H. Frye. 1976. Stand ratings for spruce beetles. USDA Forest Service Research Note RM-309, 4 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Appendix I

Once data for a specific stand has been isolated from the data file for all the stands using an add command in the Univac 1100 text editing routine from the Univac Manual UP-8723, program processing requires no additional input. The inventory file for the stand is searched by the program for information required for computation of stand spruce beetle susceptibility index. The program calls USDA Forest Service subroutine ESSITE for computation of site index based on Alexander (1967). On output, the program lists:

1. Alexander's site index
2. Total number of trees processed
3. Number of sample trees with d.b.h. greater than 2.6 inches

4. Number of sample spruce with d.b.h. greater than 10.0 inches
5. Stand risk rating from Schmid and Frye (1976)

Schmid/Frye Value	Program Output
4-5	Low
6	Low Medium
7-9	Medium
10	Medium High
11-12	High
See example problem	

Appendix II

Program listing

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C      ----PROGRAM TO ESTIMATE SUSCEPTIBILITY OF A SPRUCE STAND TO
C      ----SPRUCE BEETLE ATTACK
C
C      ----DATA INPUT IS STANDARD REGION-2 STAGE I/II STAND DATA
C      ----IT IS ASSUMED THAT DATA IS FOR SPRUCE STANDS ONLY
C      ----AS MANY SPRUCE STANDS AS NECESSARY CAN BE INPUTED AT ONE TIME
C *****-----USE UNIT 7 FOR DATA INPUT
C      DIMENSION X(4),IASCI(2,5),ASI(20),ITITL(12)
C      DATA IASCI/4HHIGH,1H ,4HMED ,4HHIGH,4HMEDI,2HUM,4HLOW ,3HMED,
C      13HLOW,1H /
C
C      ...
C      ... TDBH = TOTAL LIVE DBH .GT. 2.6 IN
C      ... TSDBH = TOTAL LIVE SPRUCE .GT. 2.6 IN
C      ... TC = TOTAL DBH IN CANOPY .GT. 2.6 IN
C      ... TSC = TOTAL SPRUCE IN CANOPY .GT. 2.6 IN
C      ... SDBH10 = TOTAL SPRUCE .GT. 10. IN REGARDLESS OF POSITION
C      ... XBAI IS BASIAL AREA INDEX
C      ... XHI = TREE HEIGHT
C      ... NUM=NUMBER OF ADDITIONAL STEMS
C      ... XAGE = TREE AGE
C      ...
C      ...
C      ... ICNT = COUNTER FOR TOTAL TREES PROCESSED
C      ... ICNT2 = COUNTER FFR TREES OVER 2.6 IN. DBH
C      ... ICNT3 = COUNTER FFR SPRUCE OVER 10. DBH
C      ... NPLTS = COUNTER FOR NUMBER OF PLOTS
C      ... IPLTS1 = SECOND PLOT COUNTER
C      ... ISITC = COUNTER FOR SITE TREES
C      ...

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C ... RSK = SITE INDEX
      TDBH=0.
      TSDBH=0.
      TC=0.
      TSC=0.
      SDBH10=0.
      IUNIT=7

C
C ... READ HEADER CARD
197 CONTINUE
      NPLTS=0
      IPLTS1=0
      ICNT=0
      ICNT2=0
      ICNT3=0
      ISITC=0
      IEND=0
      READ(IUNIT,198,END=98) IDX1,IDX2,(ITITL(I),I=1,12)
198 FORMAT(2I6,1X,11A6,A1)
      IUNIT=7
C ... DUMMY READ LOOP TO GET AT DATA
20 READ(IUNIT,199,END=98) ICT,IASCI2,IASCI1
C WRITE(6,199)ICT,IASCI2,IASCI1
199 FORMAT(12X,I1,16X,A2,8X,A1)
      IF(ICT.NE.2)GO TO 21
      DECODE(1,501,IASCI1)IRSK
501 FORMAT(I1)
C ...
C ... XBAl IS BASAL AREA INDEX FROM INPUT
555 FORMAT(10X,"IRSK,XBAl",I5,10X,1PE14.7)
C ...
      DECODE(2,502,IASCI2)XBAl
C WRITE(6,555)IRSK,XBAl
502 FORMAT(F2.0)
      GO TO 20
21 CONTINUE
      IF(ICT.NE.8)GO TO 20
C ... READ DATA CARDS
1 READ(IUNIT,101,END=98,ERR=99)ISIT1,ISIT2,ICT,IPLTS,ITH,ITSP,DBH,
1XHI,NUM,XAGE,ITPOS
101 FORMAT(2I6,I1,I3,7X,I2,I3,F3.1,F3.0,I2,5X,F3.0,10X,I1)
C ----CHECK FOR NEW STAND
      IF(ICT.EQ.1) GO TO 505
C ... ISIT = SITE ID
C ... ICT= CARD TYPE
C ... ITH = TREE HISTORY -- "01" IS LIVE TREE -- "99" IS SITE TREE
C ... ITSP = TREE SPECIES
C ... DBH = DBH
C ... IRSK = PHYSIOLOGICAL LOCATION "IRSK=8 .THEN. HIGH RISK
C ...
C ... BRANCH TO READ IF NOT LIVE TREE
      IF(IPLTS.NE.IPLTS1)NPLTS=NPLTS+1
      IPLTS1=IPLTS
C ... CHECK FOR SITE TREE
      IF(ITH.EQ.1)GO TO 2
      IF(ITH.NE.99)GO TO 1
C ...
C ... TREE IS SITE TREE
C ... ASSUME TREE IS SPRUCE
C ... FROM FOREST SERVICE SUBROUTINE
      ISITC=ISITC+1
      CALL ESSITE(XHI,XAGE,ASI(ISITC))
      GO TO 1
2 CONTINUE
      NUM=NUM - 1
      IF(NUM.LT.0) NUM=0
      ICNT=ICNT + 1 + NUM
      NUM=0
C ... DISREGARD TREE IF LESS THAN 2.6 IN.
      IF(DBH.LT.2.6)GO TO 1
      ICNT2=ICNT2+1
      DDDH=(DBH/2.)/12.
      DDH=DDDH*DDDH*3.2425962
C WRITE(6,500)DBH,DDDH
500 FORMAT(10X,2(1PE14.7))
      TDBH=TDBH+DDDH
      IF(ITSP.GT.90)TSC=TSC+DDDH
      IF(DBH.LT.10.)GO TO 1

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        IF(ITSP.LT.90)GO TO 1
        ICNT3=ICNT3+1
        SDBH10=SDBH10+DBH
        GO TO 1
98      IEND=1
        GO TO 505
55      CONTINUE
C      ----CHECK FOR ERROR IN DATA FORMAT
        IF(ICT.EQ.1) GO TO 505
        WRITE(6,504) ISIT1,ISIT2
504      FORMAT(" THERE HAS BEEN AN ERROR IN READING THE DATA FOR"
1        " STAND ",2I6,/, " RUN TERMINATED")
        STOP
505      CONTINUE
        IF(IPLTS1.EQ.NPLTS)GO TO 7
C      WRITE(6,503)NPLTS
503      FORMAT(10X,"ERROR -- PLOT NUMBER AND COUNT NOT EQUAL",
1        1/,10X,"NUMBER OF PLOTS COMPUTED AS = ",I4)
7        CONTINUE
C      ... COMPUTE AVERAGE DIAMETER OF LIVE SPRUCE ABOVE 10. IN. DBH
C      ... -- ALL LIVE SPRUCE TREES USED, BOTH CANOPY AND UNDERSTORY
        IF(ICNT3.GT.0)GO TO 10
        WRITE(6,300)
300      FORMAT(10X,"STAND CONTAINS ZERO SPRUCE ABOVE 10. IN. DBH",/
1        1,10X,"VARIABLE X(2) SET TO ZERO")
        X(2)=0.
        GO TO 19
10       X1=FLOAT(ICNT3)
C      ... * * NOTE XBAl IS BASAL AREA INDEX * *
        X(2)=SDBH10/X1
19       CONTINUE
C      ... COMPUTE TOTAL STAND DBH REGARDLESS OF SPECIES OR TREE POSITION
C      ... TREES MUST BE GREATER THAN 2.6 DBH TO BE INCLUDED
        X1=ICNT2
        X2=NPLTS
        X(3)=(X1/X2)*XBAl
C      ... COMPUTE PERCENT SPRUCE IN CANOPY - TREES .GT. 2.6 DBH ONLY
        X(4)=100.*(TSC/TDBH)
C      ... CONVERT RAW VALUES TO RISK VALUES
C      WRITE(6,900)X(1),X(2),X(3),X(4)
900      FORMAT(10X,4(1PE14.7))
C      ... SITE INDEX
        IF(ISITC.LE.0)GO TO 600
C      WRITE(6,*)"ISITC = ",ISITC
        X1=ISITC
        RSK=0.
        DO 40 I=1,ISITC
C      WRITE(6,*)"ASI(",I,") = ",ASI(I)
        RSK=RSK+ASI(I)
40       CONTINUE
        RSK=RSK/X1
        X(1)=2.
        IF(RSK.LT.80.)X(1)=1.
C      ... CHECK FOR CREEK BOTTOM OR DRAW
        IF(IRSK.EQ.8)X(1)=3.
C      ... BEGIN OUTPUT
        WRITE(6,603)(ITITL(I),I=1,12)
603      FORMAT(/,10X,"SPRUCE BEETLE STAND RATING FOR ",11A6,A1)
        WRITE(6,601)RSK
601      FORMAT(10X,"ALEXANDERS SITE INDEX = ",F10.4)
        X1=X(2)
        X(2)=3.
        IF(X1.LT.16.)X(2)=2.
        IF(X1.LT.12.)X(2)=1.
        X1=X(3)
        X(3)=3.
        IF(X1.LT.150.)X(3)=2.
        IF(X1.LT.100.)X(3)=1.
        X1=X(4)
        X(4)=3.
        IF(X1.LT.65.)X(4)=2.
        IF(X1.LT.50.)X(4)=1.
C      ... COMPUTE RISK SCORE
        XRSK=0.
        DO 30 I=1,4
        XRSK=XRSK+X(I)
30       CONTINUE
        IOUT=1

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      IF(XRSK.LT.11.)IOUT=2
      IF(SRSK.LT.10.)IOUT=3
      IF(XRSK.LT.7.)IOUT=4
      IF(XRSK.LT.6.)IOUT=5
      WRITE(6,301)ICNT,ICNT2,ICNT3,(IASCI(I,IOUT),I=1,2)
301  FORMAT(10X,/,
110X,"TOTAL TREES PROCESSED IN STAND = ",I3,
2/10X,"TREES PROCESSED WITH DBH %2.6 IN. = ",I3,/
310X,"TREES PROCESSED WITH DBH%10.0 IN. = ",I3,///
410X,"STAND RISK RATING FOR SPRUCE BEETLE IS ",2A4,/)
C      ----CHECK TO SEE IF END OF DATA
      IF(IEND.NE.0) STOP
C      ----REREAD TITLE CARD FOR NEW STAND AND BEGIN PROCESSING NEW STAND
      IUNIT=30
      GO TO 197
600  CONTINUE
      WRITE(6,602)
602  FORMAT(10X,"NO SITE TREES -- PROGRAM ABORT")
      STOP
      END
      SUBROUTINE ESSITE(HT,AGE,SITE)
C  SUBROUTINE TO COMPUTE SITE INDEX FOR ENGELMANN SPRUCE-REFERENCE
C  ALEXANDER 1967 RESEARCH PAPER RM-32 TABLE 1.
C  INPUT TREE HEIGHT (HT) AND BREAST HEIGHT AGE(AGE). OUTPUT SITE INDEX
C  (SITE).
      DIMENSION HTSI(30,10), HROW(10), AG(30), SI(10)
      DATA HTSI/30*0.,4.5,6.,11.,15.,20.,24.,29.,33.,37.,40.,43.,46.,48.,
1,51.,53.,55.,56.,58.,59.,60.,61.,62.,2*63.,6*64.,4.5,9.,16.,22.,28.,
2.,33.,38.,42.,46.,50.,53.,56.,59.,61.,64.,66.,67.,69.,70.,71.,72.,
373.,2*74.,6*75.,4.5,13.,22.,29.,36.,42.,47.,52.,56.,60.,64.,67.,70.,
4.,72.,74.,76.,78.,80.,81.,82.,83.,84.,2*85.,6*86.,4.5,16.,27.,36.,
544.,50.,56.,61.,66.,70.,74.,77.,80.,83.,85.,87.,89.,90.,92.,93.,94.,
6.,2*95.,2*96.,5*97.,4.5,20.,33.,43.,52.,59.,65.,70.,75.,80.,84.,88.,
7.,91.,94.,96.,98.,100.,101.,103.,104.,105.,2*106.,2*107.,5*108.,4.,
85.,23.,39.,50.,59.,67.,74.,80.,85.,90.,94.,98.,101.,104.,107.,109.,
9111.,112.,114.,115.,116.,2*117.,3*118.,4*119.,4.5,27.,44.,57.,67.,
176.,83.,89.,95.,100.,105.,109.,112.,115.,118.,120.,122.,123.,125.,
2126.,2*127.,128.,3*129.,4*130.,4.5,30.,50.,64.,75.,84.,92.,98.,104.,
3.,110.,115.,119.,123.,126.,129.,131.,133.,134.,135.,136.,137.,138.,
4.,139.,3*140.,4*141.,4.5,34.,55.,71.,83.,93.,101.,108.,114.,120.,12.,
55.,130.,133.,136.,139.,142.,144.,145.,146.,147.,148.,149.,2*150.,2.,
6*151.,4*152./
      DATA AG/0.,20.,30.,40.,50.,60.,70.,80.,90.,100.,110.,120.,130.,140.,
1.,150.,160.,170.,180.,190.,200.,210.,220.,230.,240.,250.,260.,270.,
2,280.,290.,300./
      DATA SI/0.,40.,50.,60.,70.,80.,90.,100.,110.,120./
      DATA HROW(1)/0./
      TEM=AGE
      IF(TEM.GT.300.)TEM=300.
      DO 10 I=2,30
      I1=I-1
      I2=I
      IF(AG(I)-TEM) 10,20,20
10  CONTINUE
20  DO 30 J=2,11
      J1=J-1
      J2=J
      HROW(J)=(HTSI(I1,J)*(TEM-AG(I2))-HTSI(I2,J)*(TEM-AG(I1)))/(AG(I1)-
1AG(I2))
      IF(HROW(J)-HT) 30,40,40
30  CONTINUE
40  IF(HROW(J)-HT) 50,60,60
50  SITE=120.
      RETURN
60  SITE=(SI(J1)*(HT-HROW(J2))-SI(J2)*(HT-HROW(J1)))/(HROW(J1)-HROW(J
1))
      RETURN
      END

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Appendix III

Example Run

- A. Data
- B. Program Execution
- C. Output

@DATA,L SPRUCEDATA.

DATA 9R1 SL74T9 08/15/80 09:23:57 (1)

1.	1037070016121386	WILLIAMS CREEK				
2.	1037070016122020	94206797 00530300	01032	01X	GA0111	
3.	103707001612408055031111010000000002			01		
4.	1037070016126F16C008G137742300203621025S068W06					115
5.	1037070016128 0016					
6.	103707001612900101	01093077025	18039	008200		1
7.	103707001612900102	01093128041	09156	018255		1
8.	103707001612900103	01093070028		009200		1
9.	1037070016129001	0109304001501		8		
10.	103707001612900104	01093000000	008	029	0 00	2
11.	103707001612900105	01093000001			0 00	2
12.	103707001612900106	01093000004			0 00	2
13.	103707001612900201	01093159058	08168	019227		1
14.	103707001612900202	01093182057	06224	019227		1
15.	103707001612900203	01093058028	05090	008355		2
16.	103707001612900204	01093144055	06220	009227		1
17.	103707001612900205	01093140045		029227		1
18.	103707001612900206	01093080033		019300		2
19.	103707001612900207	01093027013	02804051	09300		2
20.	103707001612900208	01093040019	02809065	09300		2
21.	103707001612900209	01093033016		09300		2
22.	103707001612900210	01093000003		0 00		2
23.	103707001612900301	06093161024				3
24.	103707001612900302	01102118025		8		2
25.	103707001612900303	01102178027		8		2
26.	103707001612900304	06102116021				3
27.	103707001612900305	01093071027		009300		1
28.	103707001612900306	01093056024		008300		2
29.	103707001612900307	01093197046	05189	248252		1
30.	103707001612900308	01093186048		148252		1
31.	103707001612900309	01093065028		019255		1
32.	103707001612900310	01093025012		08472		2
33.	103707001612900311	01093028012		07451		2
34.	103707001612900312	01093026009		07451		2
35.	103707001612900313	01093015008		07451		2
36.	103707001612900314	01093010007		07451		2
37.	103707001612900401	01093090024		487228		2
38.	103707001612900402	01093131028		029255		1
39.	103707001612900402	99093131028	068	9255		2
40.	103707001612900501	01093117034		008200		2
41.	103707001612900502	01093071030		017255		2
42.	103707001612900503	01093228075	06200	007255		1
43.	103707001612900504	01093094033		008200		2
44.	103707001612900505	01093013007		08400		2
45.	103707001612900506	01093000001		0 00		2
46.	103707001612900507	01093000000		0 00		2
47.	103707001612900508	01093000000		0 00		2
48.	103707001612900501	99093117034	048	8200		2

49. 103707001612900503 99093228075 200 7255 2
END DATA. ERRORS: NONE. TIME: 0.723 SEC. IMAGE COUNT: 49

@FIN

@RUN,J/S R2TMR,1102602411 ,INVADP,1,75/2000

@ASG,A SPRUCEDATA.

@ASG,A SPRUCEBEETLE.

@USE 7, SPRUCEDATA.

@XQT SPRUCEBEETLE.XQT

SPRUCE BEETLE STAND RATING FOR 386 WILLIAMS CREEK
ALEXANDERS SITE INDEX = 50.9557

TOTAL TREES PROCESSED IN STAND = 39
TREES PROCESSED WITH DBH >2.6 IN. = 28
TREES PROCESSED WITH DBH>10.0 IN. = 12

STAND RISK RATING FOR SPRUCE BEETLE IS MEDIUM

@FIN



Rocky
Mountains



Southwest



Great
Plains

U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

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